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Quantum information science on the frontier

Jake Taylor
Office of Science and Technology Policy
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For DG Connect members only

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EXPANDING AMERICAN LEADERSHIP IN QUANTUM INFORMATION SCIENCE

Jake Taylor
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QUANTUM INFORMATION TECHNOLOGY

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Measure beyond the limits of individual particles — use entanglement (Adv. LIGO, dual ion clock)

Quantum communication

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Quantum simulation

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How do we operate in a post-quantum world?

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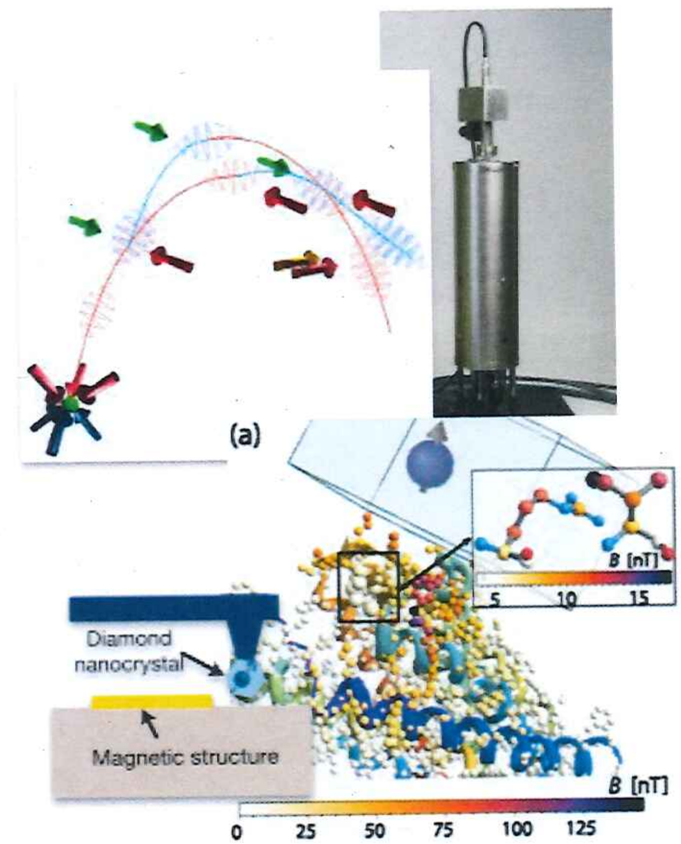
MRI (medicine)

Lasers

Atomic clocks (GPS!)

Quantum-limited sensors



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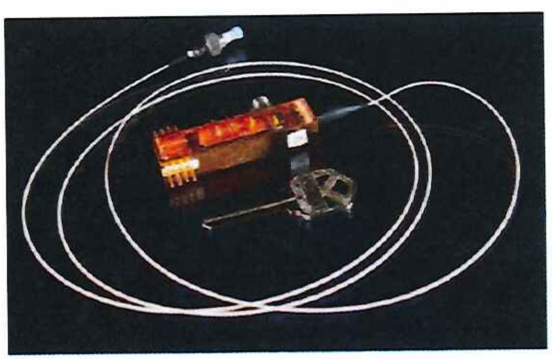

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Recall: Simulating quantum mechanics is hard…

Solution: Use one system to simulate another

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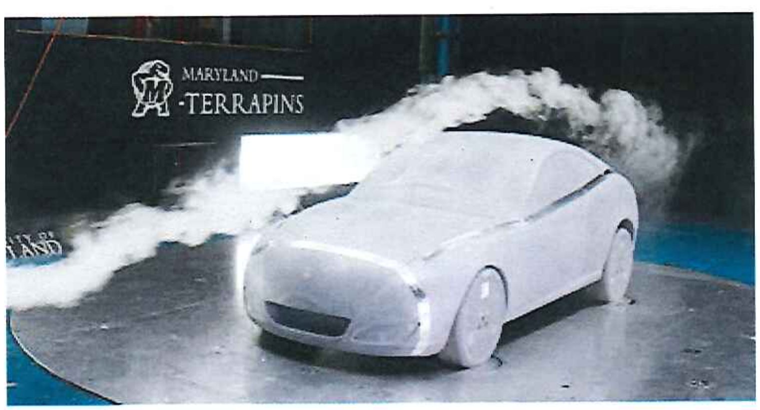
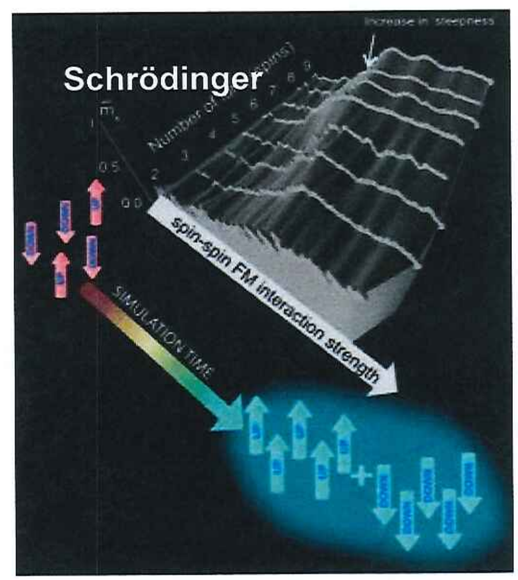




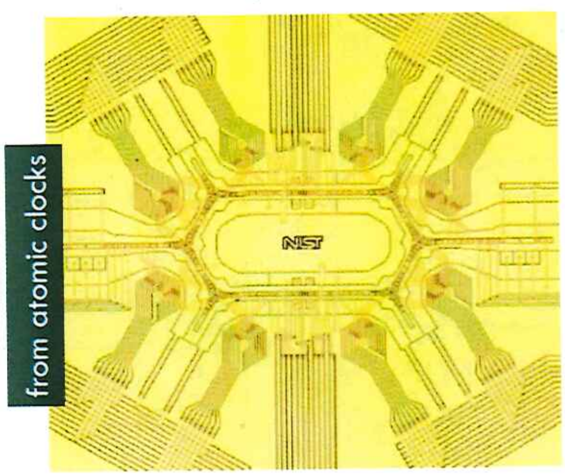
TOWARDS QUANTUM COMPUTATION

Ideal case: programmable quantum computer

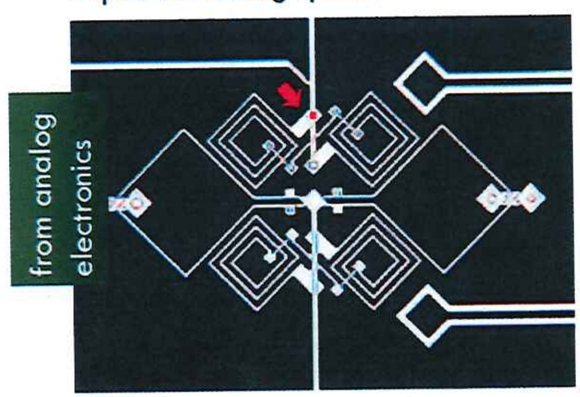
Moving from the lab to systems and engineering…

but many questions about a processor await

Atomic qubits



Superconducting qubits



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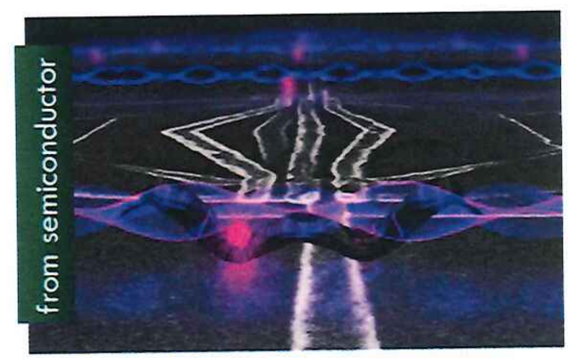
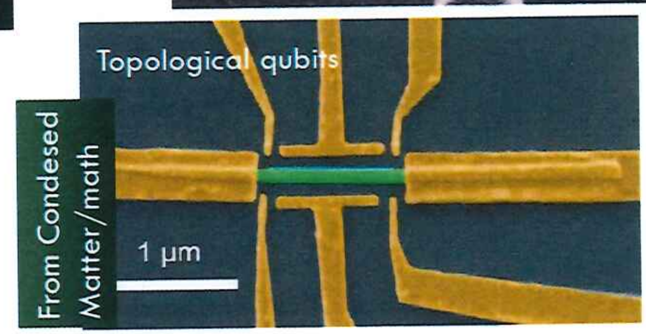




And more (photonic, impurity, …)

WHAT DO WE KNOW? WHERE CAN WE GO?

THE FIELD OF DREAMS

QUANTUM INDUSTRY: AN OPPORTUNITY

Current quantum technology: atomic clocks, nuclear magnetic resonance, modern telecom detectors and sources, LIGO, optical sensors, ...

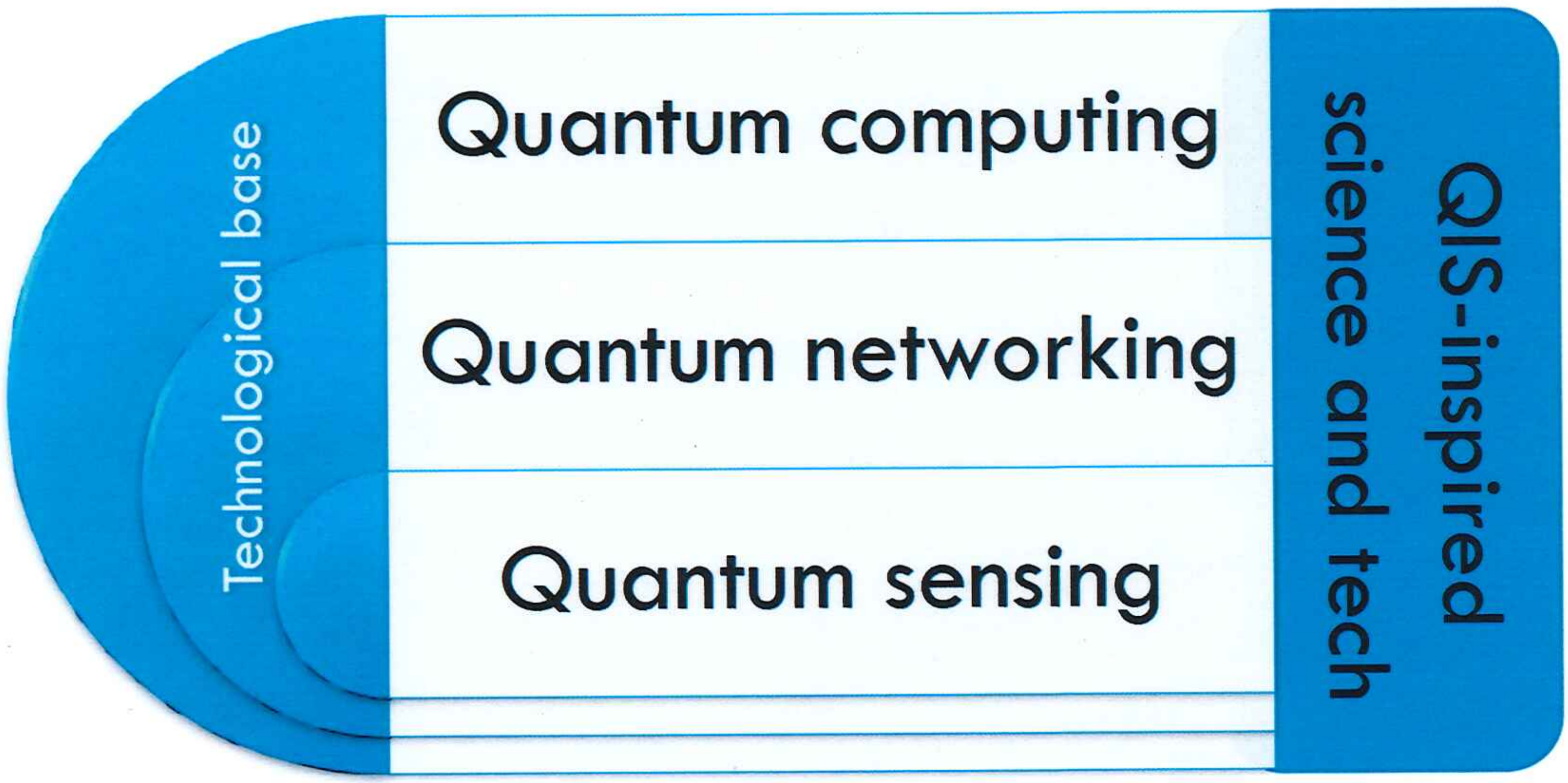
Next generation quantum?

- Improved computational approach to materials, chemistry
- Fundamental advances in condensed matter, high energy theory
- New understanding of optimization, machine learning
- Spin-offs: Quantum random number generators, new sensing modalities, better PNT, new qubit technologies, new analog microwave and optical technologies

The 10 year outlook?

- The beginnings of a sea change for corporations and government – the need to incorporate quantum computing and technologies into their business model

WHAT DOES QUANTUM INFORMATION SCIENCE POLICY COVER?



Focus on basic research!

OUR CHOICE

Invest in our talent	Enhance workforce
	Drive market opportunities
	Enable new jobs in science, engineering, and beyond
Develop public-private partnerships	Realize government multiplier for innovation economy
	Gain efficiency via division of responsibility
	Two-way knowledge transfer for improved R&D
Lead through smart policy	STEM effort for quantum engineering, masters
	Regular coordination across boundaries
	Continuous refactoring with improving knowledge

NEXT STEPS: NSTC SUBCOMMITTEE ON QUANTUM INFORMATION SCIENCE

Create and maintain
a national strategy for
Quantum information science

Coordinate current and future
efforts across the agencies

Co-chairs: DoE, NSF, NIST

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NEAR-TERM APPLICATIONS WITH NOISY DEVICES: FINDING THE KILLER APP

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Seems likely we will have very soon sufficiently complex devices that, while we know what individual qubits in those devices do, cannot predict their overall behavior using classical simulation tools.

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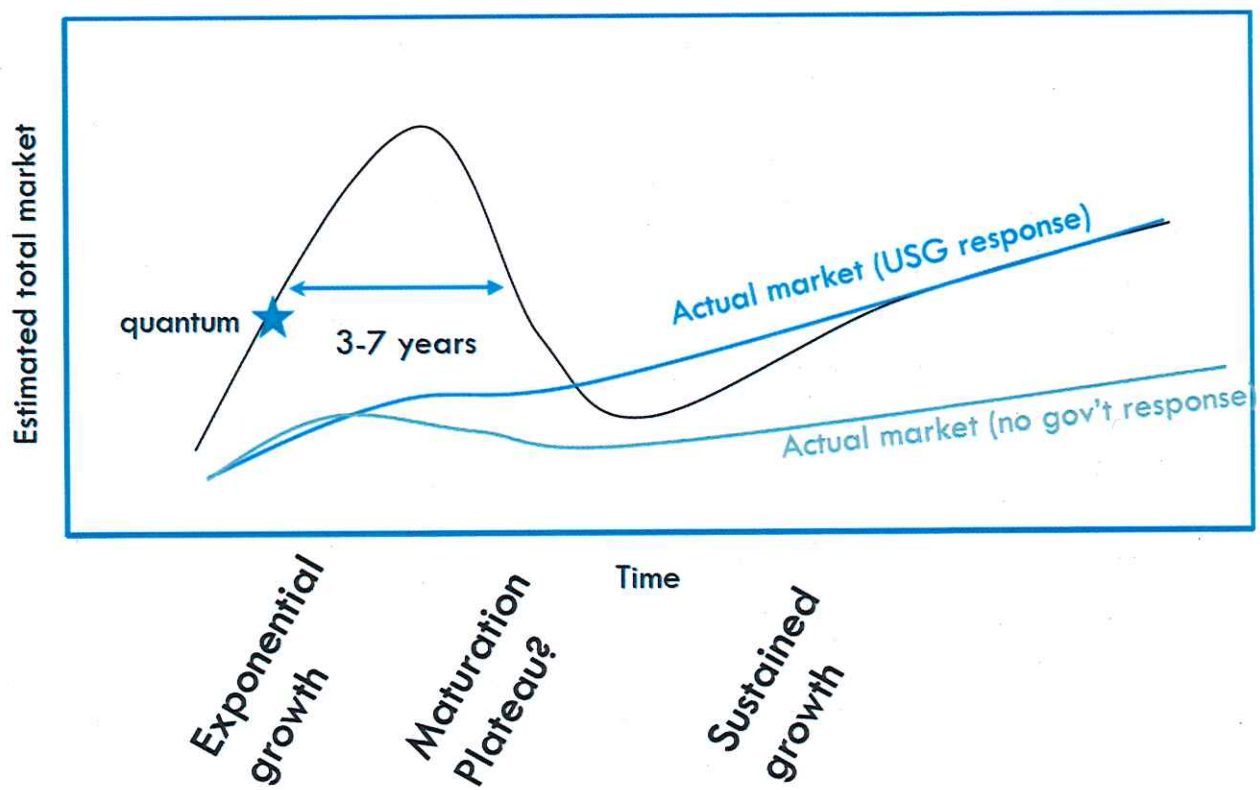
This also produces a significant challenge: **realizing a 'killer app' in this space**

WHERE ARE WE ON THE GARTNER HYPE CURVE?



QUANTUM INDUSTRY: CHALLENGES

Commercial interests are narrowly focused

- Little support for the development of new science and technology
- Primary focus on 'fast' (5 year) path to qubits without a similar path to application
- Strong risk of 'falling flat' without supportive, broad R&D quantum portfolio

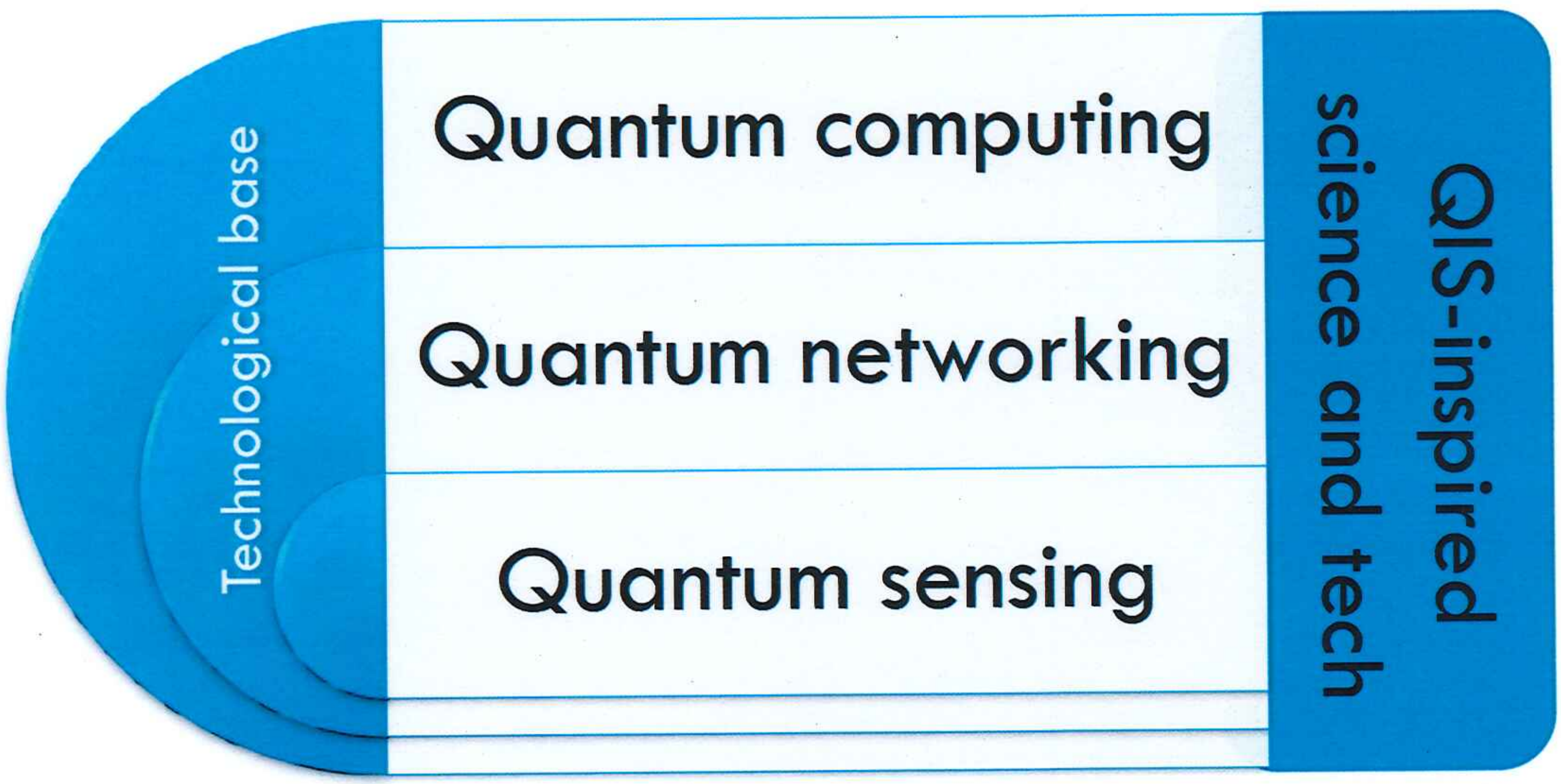
Quantum requires a highly trained, interdisciplinary workforce.

- Traditionally generated through universities, supported by basic research grants
- Weak support in QIS from the engineering, computer science communities
- Companies rarely invest in the 5-year training a PhD level requires; also rare are 2-year masters investments

Quantum requires collaboration in the pre-competitive space

- Many aspects of the opportunity space are unknown
- Companies are presently willing to engage and share, but hype can shut this down
- Venture capital investment needs to understand revenue is 10 years away

WHAT DOES QUANTUM INFORMATION SCIENCE POLICY COVER?



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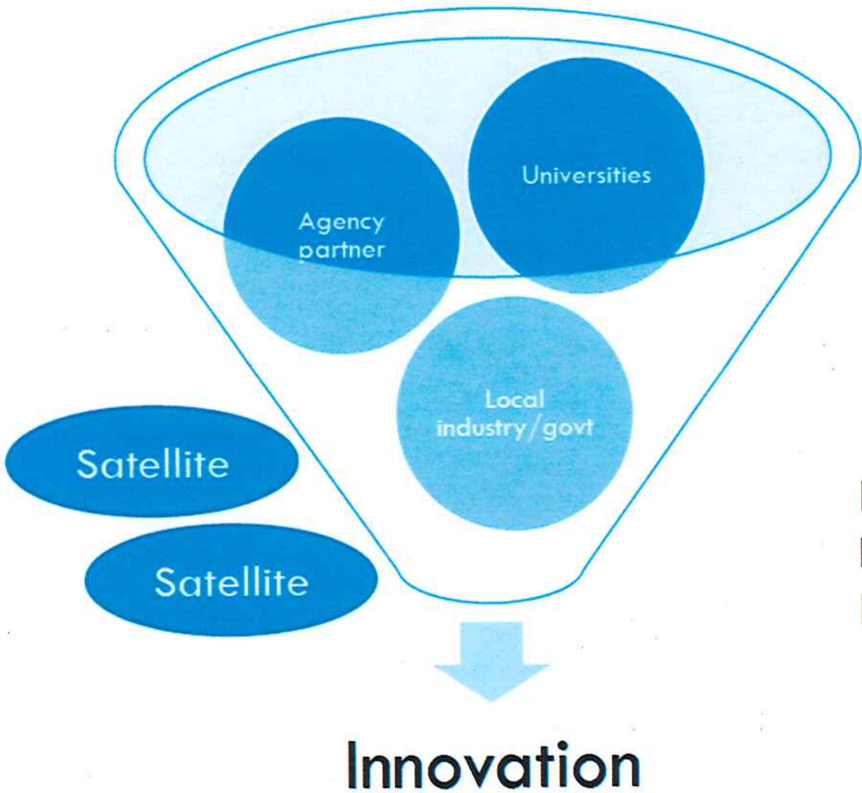


In addition:
Novel tech transfer experiments
Regular interface with OEM community
Skills training and transfer

Physical co-location
Dedicated incubation space
Long-term focus

WORKFORCE IMPROVEMENTS?

Curriculum and program development

- NSF and other agency support of QTI partners and satellites
- Workshops and reports in support of quantum engineering

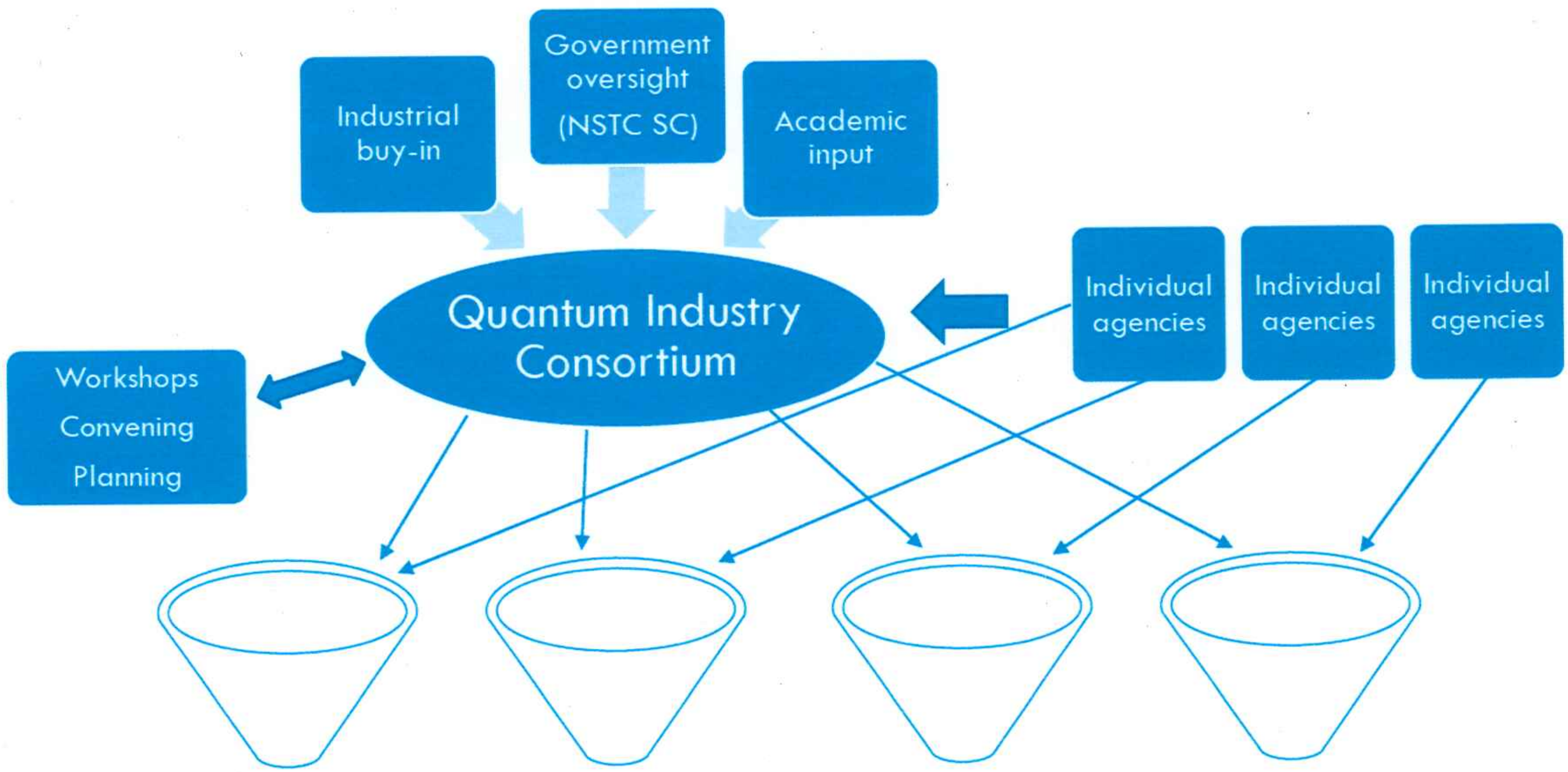
Grand challenges

- Provide a landscape of opportunity – prizes, but also planning
- A regular series convening key partners to continue tradition

Internships and externships

- National labs and industrial partners
- Incubation and acceleration fellowships

QUANTUM RESEARCH COORDINATION?



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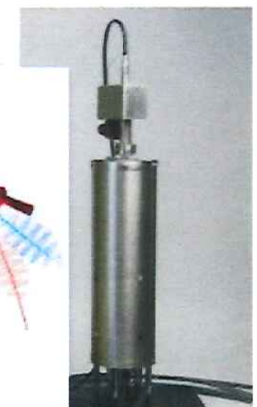

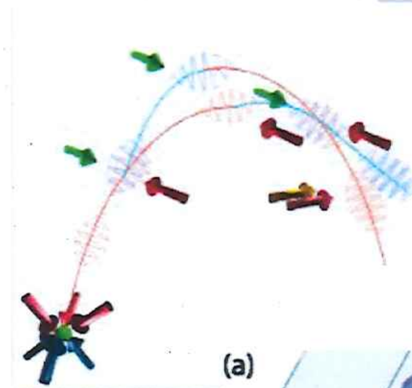

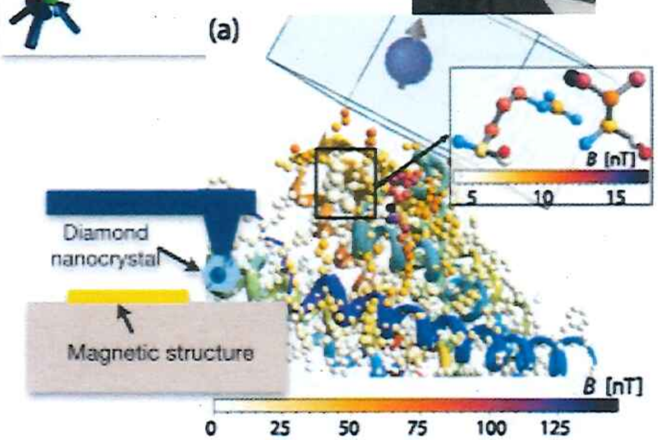

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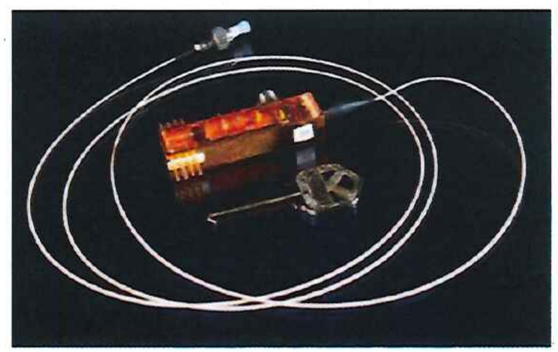

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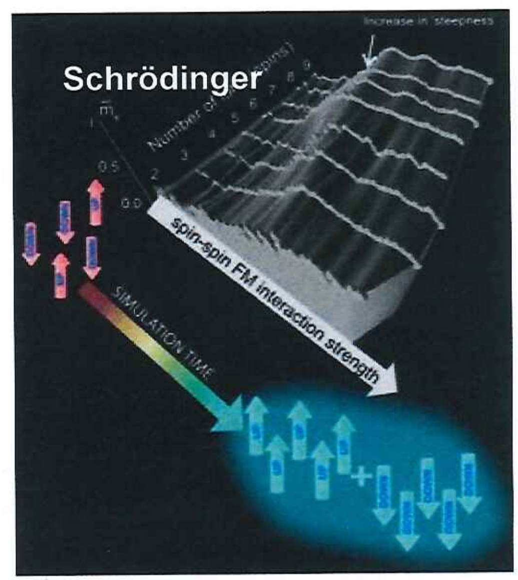

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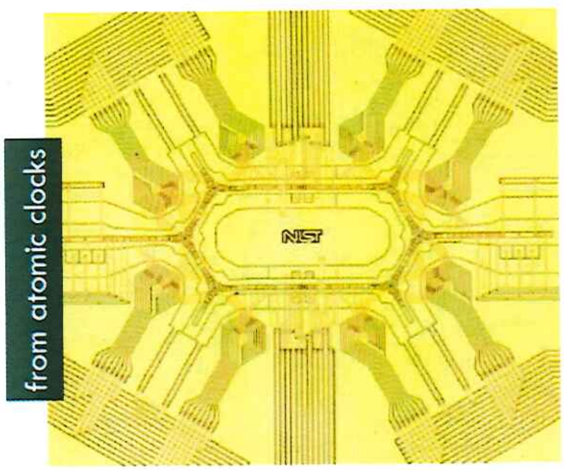

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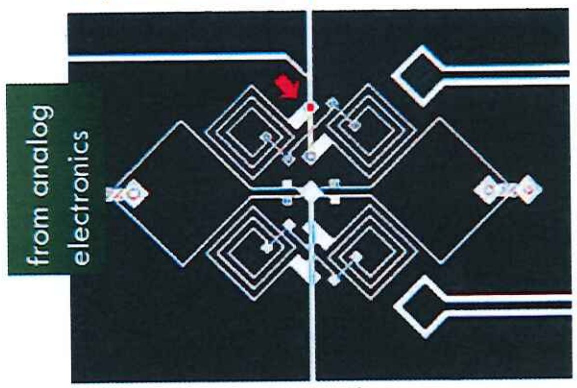

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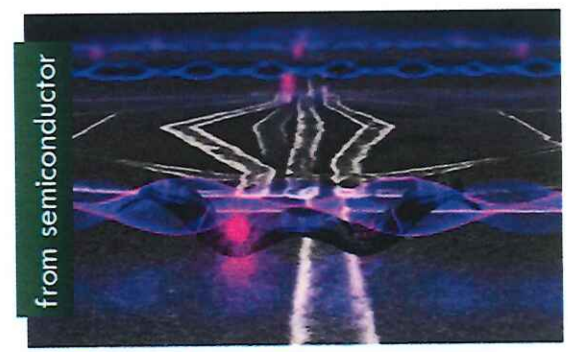

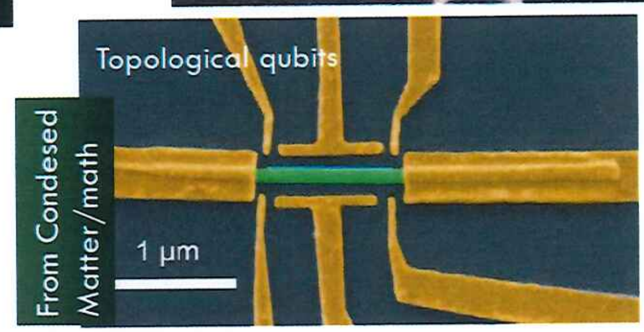

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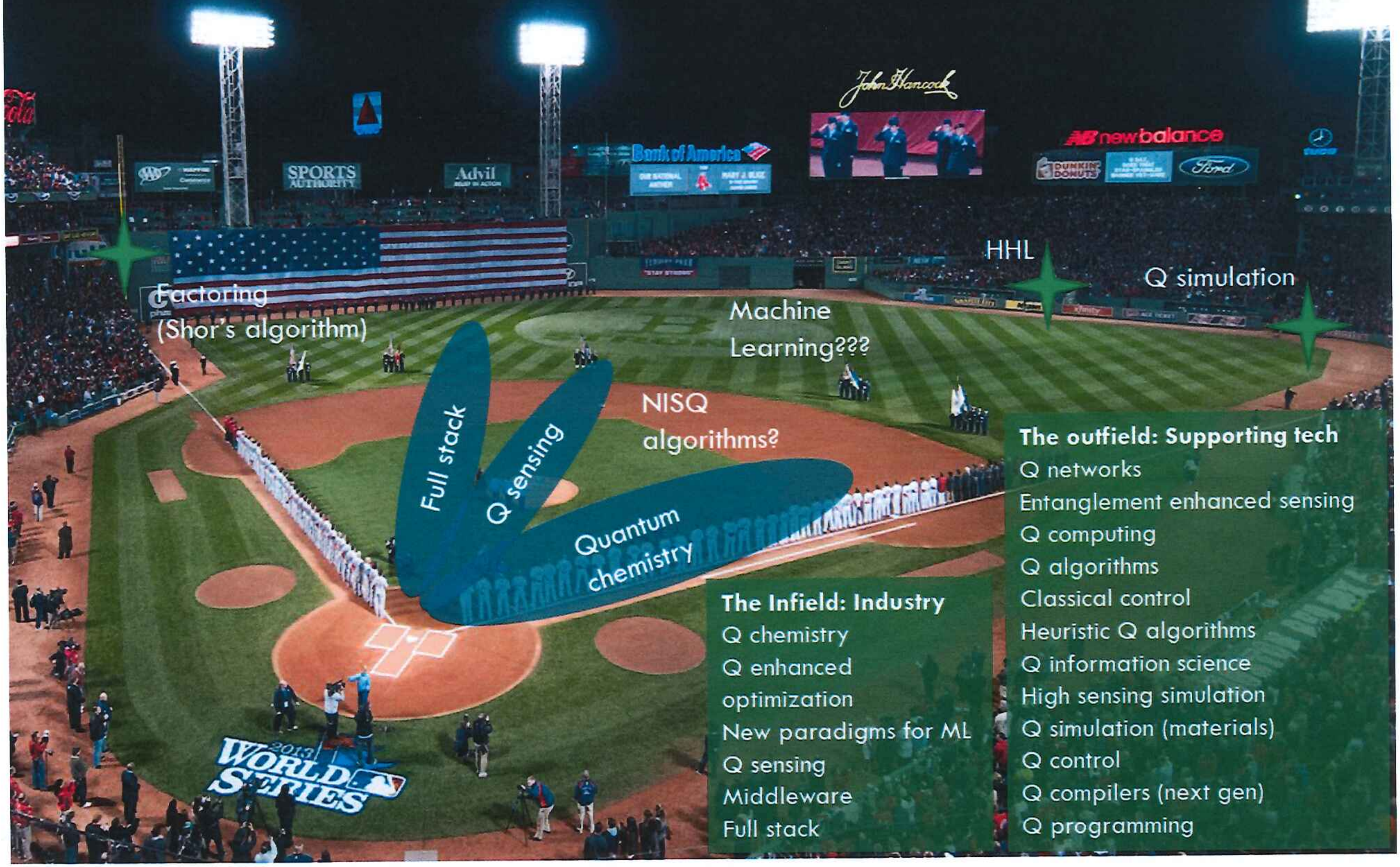

OUR STEPS FORWARD

Develop and maintain policies that enable the best and brightest to attack the hardest problems

Engage across boundaries, focusing on building key elements of the scientific and technological base

Provide a foundation for the emergence of a new industry

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